ATM Concept Demonstration 1.0 Overview

April 2002

Air Traffic Management

Environment for Change

- Current Air Traffic Control System
  - Approaching saturation
  - Periodically stressed beyond capability to manage
  - Requires close manual supervision
  - Archaic application of information technologies
- Paradigm Change
  - Trajectory-based traffic planning and management
  - Common Information Network
  - Airspace and procedures redesign
- Phased Implementation
  - Infrastructure replacement
  - Training
  - Fleet equipage

ATM Mission Drivers

Drivers

Functional

- **Quality**
  - Data Quality
  - Quality of Service
- **Links or Channels**
  - User Enabling Features
  - Coverage
  - Data Rate
  - Signal discrimination
  - Dissemination accuracy

Safety of Flight (Operational)

- **Assuredness**
  - True track
  - System Access
  - System Availability
  - Scalability
  - Reliability
  - Survivability
  - Fail-over
  - Configuration management
  - Security
  - Information Assurance
- **Timeliness**
  - Data Latency
  - Responsiveness
- **Burden**
  - Vehicle data send
  - Vehicle data receive
  - Data fusion
  - Displays – data and information
  - Flight certification
  - Transitionability

Constraints

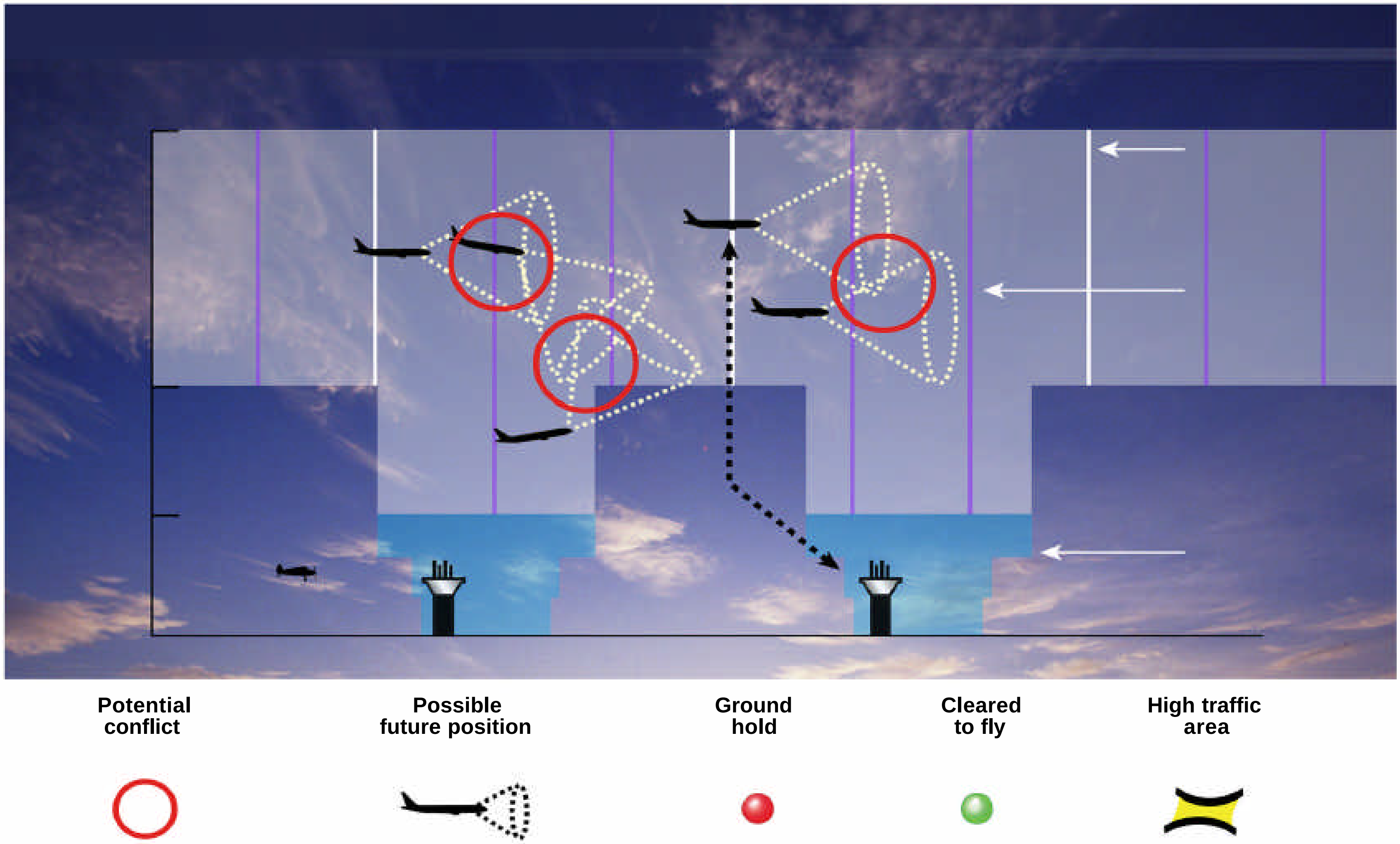
- **Cost**
  - System
  - Segment
  - Technical
- **Schedule**
  - System
  - Transition
  - Segment
  - Technical
  - Flight box certification
- **Programmatics**
  - Regulations
  - Spectrum
  - National politics
  - International politics
  - Investors

NAS Characterization

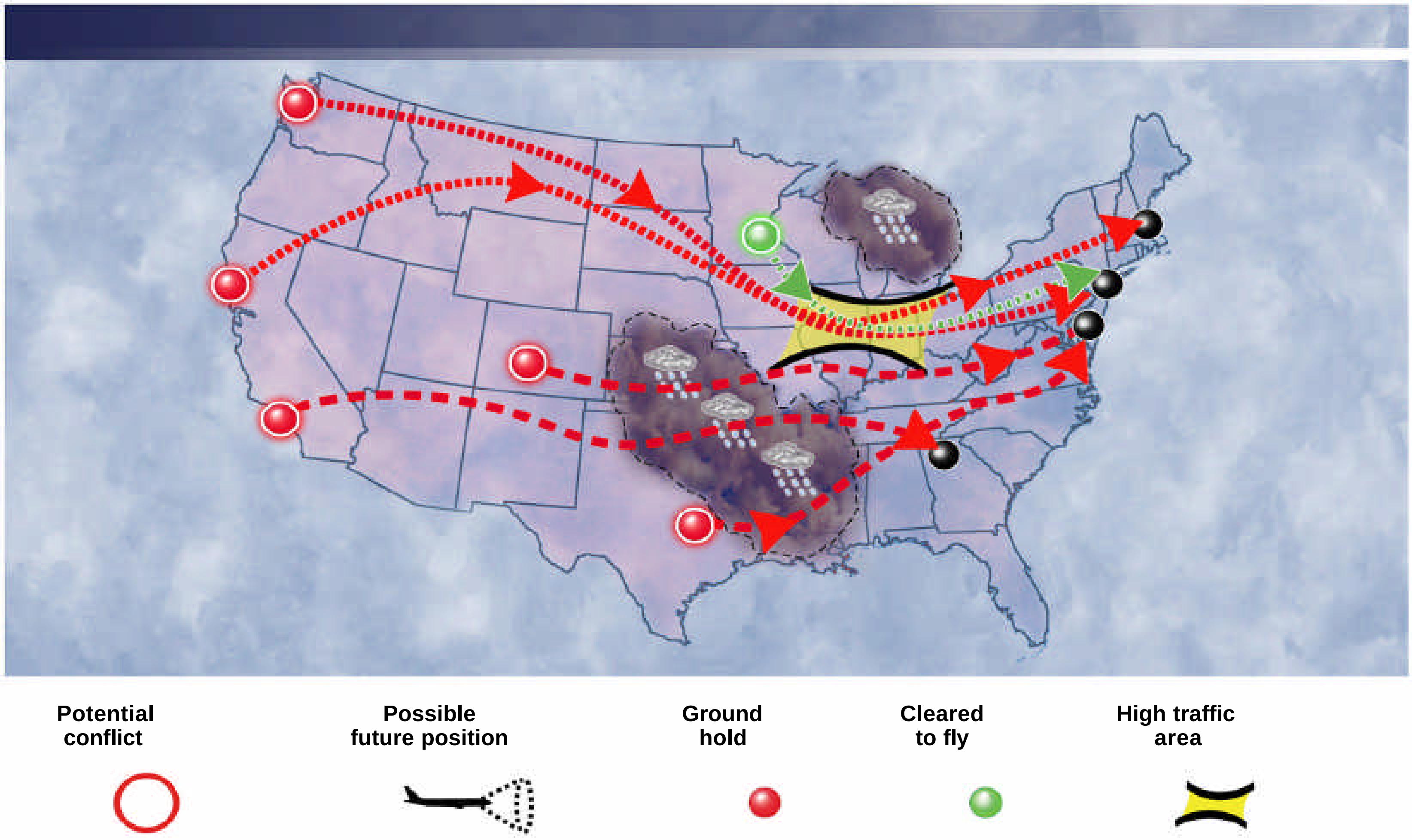
The characteristics of the current National Airspace System:

- Cone-shaped spaces ahead of the airplanes are depicted here because controller is unable to predict with great accuracy where the airplane is going to be.
- Controller sees airplane as moving dot on flat screen - has to create 3D picture in his mind of dynamic situation over time.
- As safety precaution, controllers often build in buffers.
- Many pilot-controller interventions.
- Control by rule rather than by exception.
- Increased traffic = increased workload = increased number of sectors
- Difficult to re-route airplanes once they push back from the gate.
- Airplanes restricted to fixed routings based on ground-based nav aids.
- Lengthy delays when weather conditions are bad.
- Inbound flights delayed due to gate holds.
- Full Communication, Navigation and Surveillance available at only the most capable airports.

The Current National Airspace System



The Current National Airspace System



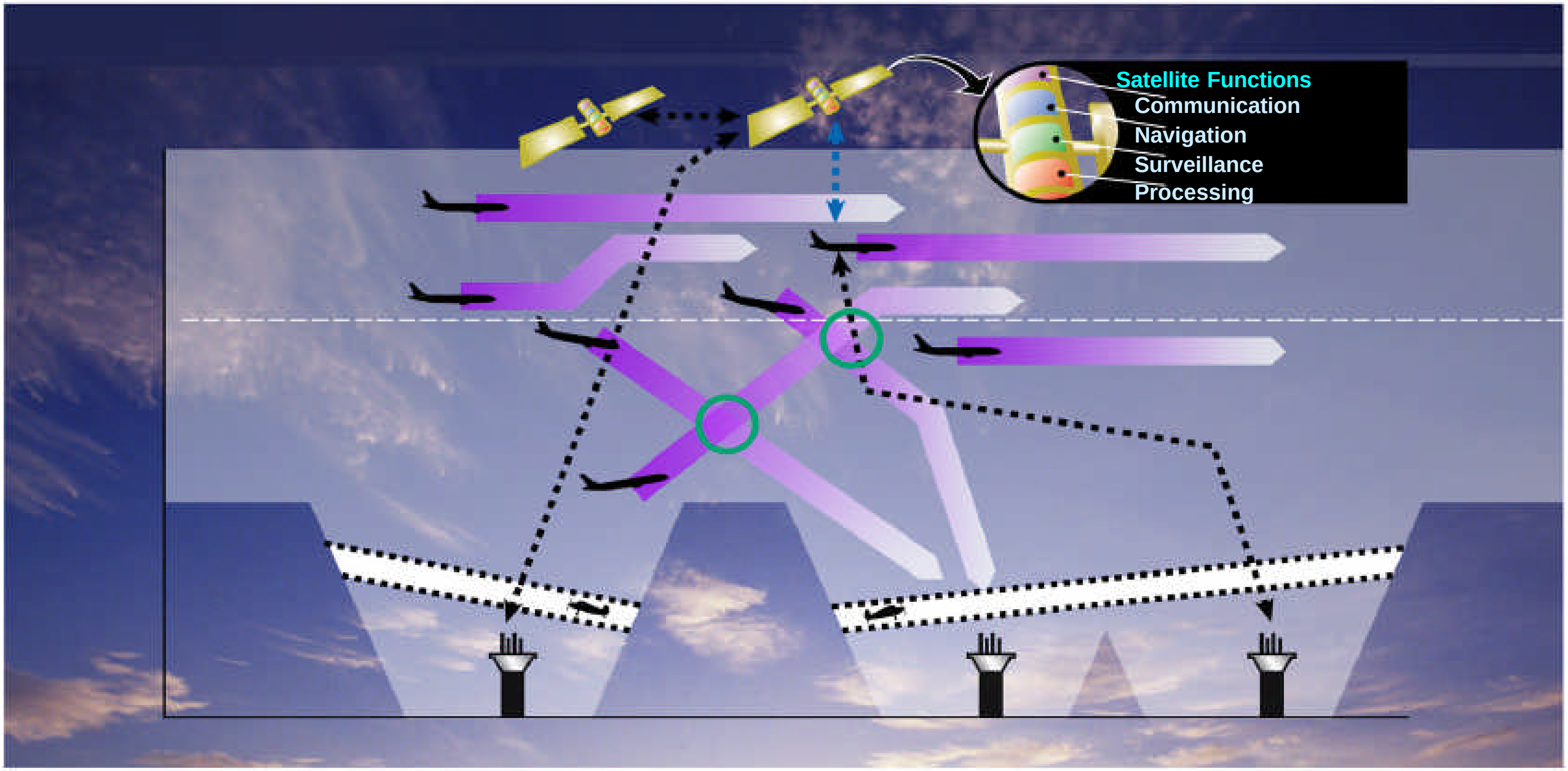
The Ideal Flight Profile

- The ideal flight profile:
  - After takeoff turn to great circle course to destination final approach fix
  - Climb unimpeded at optimum power setting and climb airspeed schedule to optimum altitude
  - Reduce power to optimum setting for initial altitude cruise
  - Cruise climb as fuel is burned and aircraft gets lighter
  - Upon reaching the ideal descent point, reduce power to optimum setting for descent and descend at optimum airspeed schedule
  - Fly an arc approach so as to cross final approach fix wings level, gear and flaps down on glide slope, and land
- Only four things preclude doing this each and every flight
  - The ground, special use airspace, the weather and other airplanes
  - Only two of these move
- ATM's basic function is to deconflict these four things
  - The basic flight plan can avoid the stationary conflicts: ground and special use airspace
  - So the basic ATM function is propagating the trajectory, and finding and resolving conflicts with the weather and other airplanes

Integrated Total System Solution

- 3 fundamental features enable true free flight
  - Trajectory-based flow planning, traffic planning and separation management - Two-way data links integrate precise on-aircraft data into airspace system.
  - Common information network – Fuses all air traffic data to allow dynamic flight path revision and provide a common operational picture.
  - Airspace design and procedures criteria– Dramatically simplifies the airspace, moving to a strategic management framework.
- Key system elements to achieve features
  - Trustworthy and timely true track knowledge required for trajectory-based system
  - Advanced space-based Communications, Navigation and Surveillance (CNS)
  - Open system architecture principles – growth for the future
  - Current and future IT capabilities required to achieve commonality, timeliness, and reliability

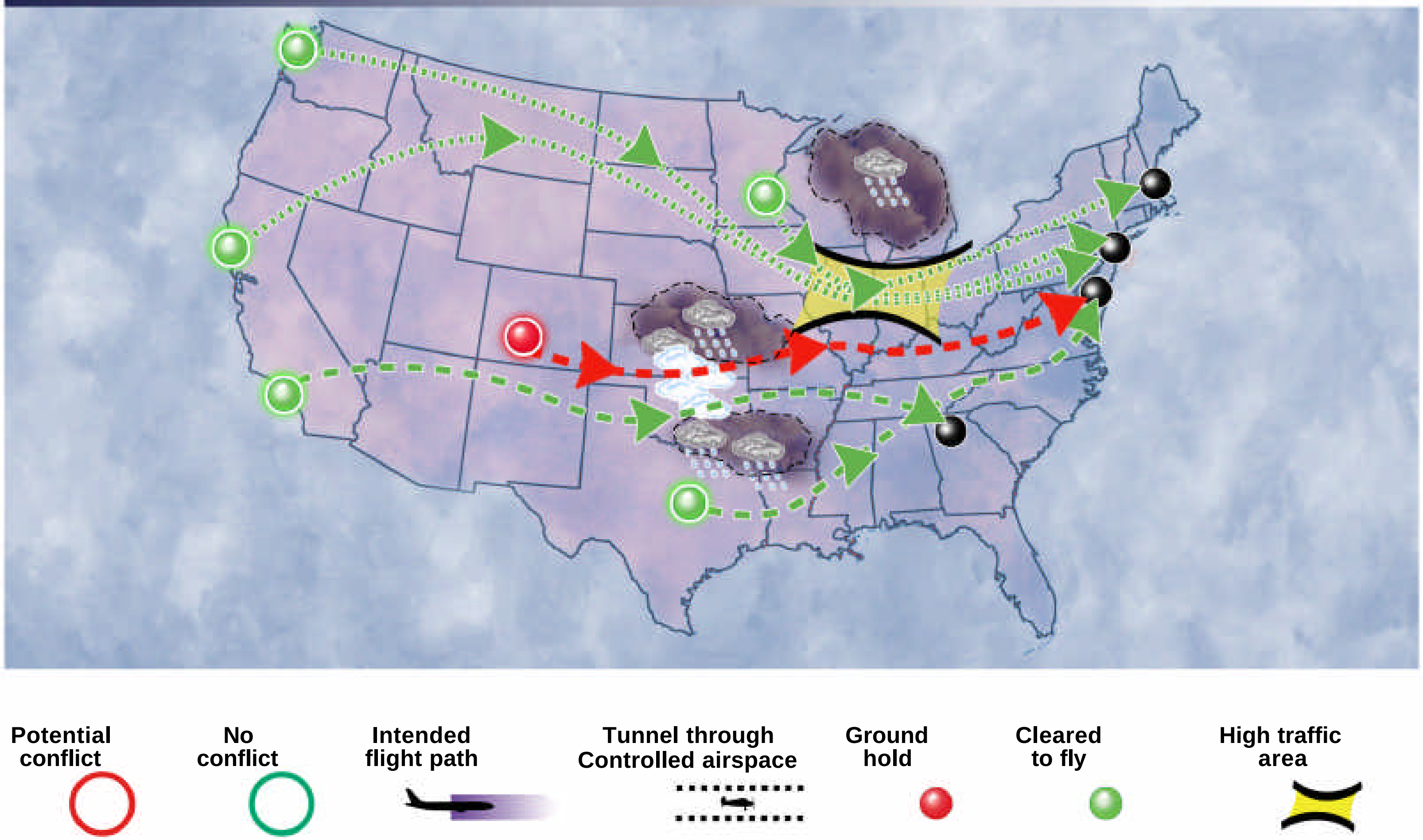
Trajectory-based Airspace



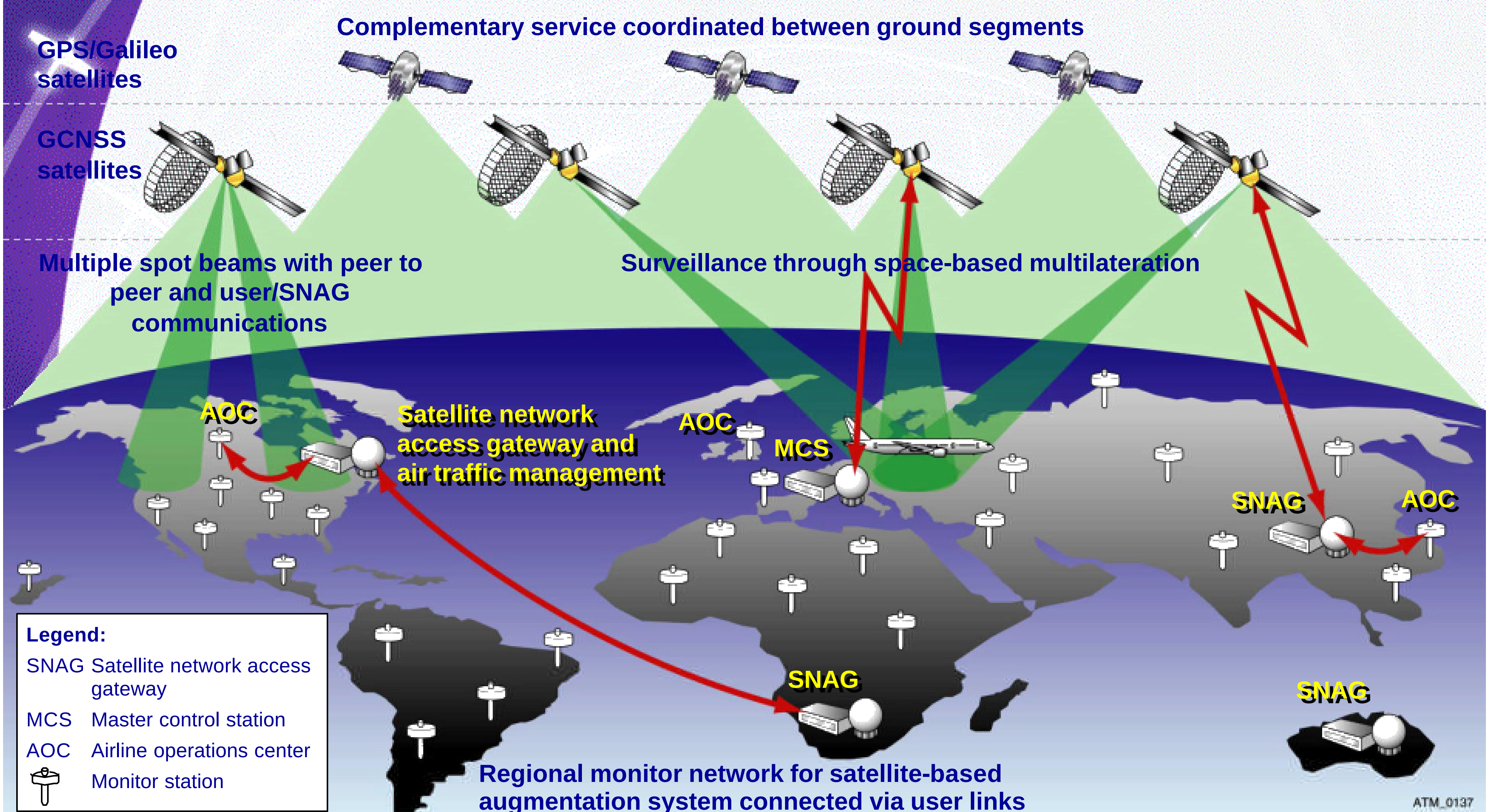
Potential conflict	No conflict	Intended flight path	Tunnel through Controlled airspace	Ground hold	Cleared to fly	High traffic area

Trajectory-based Airspace

Robust, Adaptive Flow Control



Global CNS System Architecture



Demonstration Program Mantra

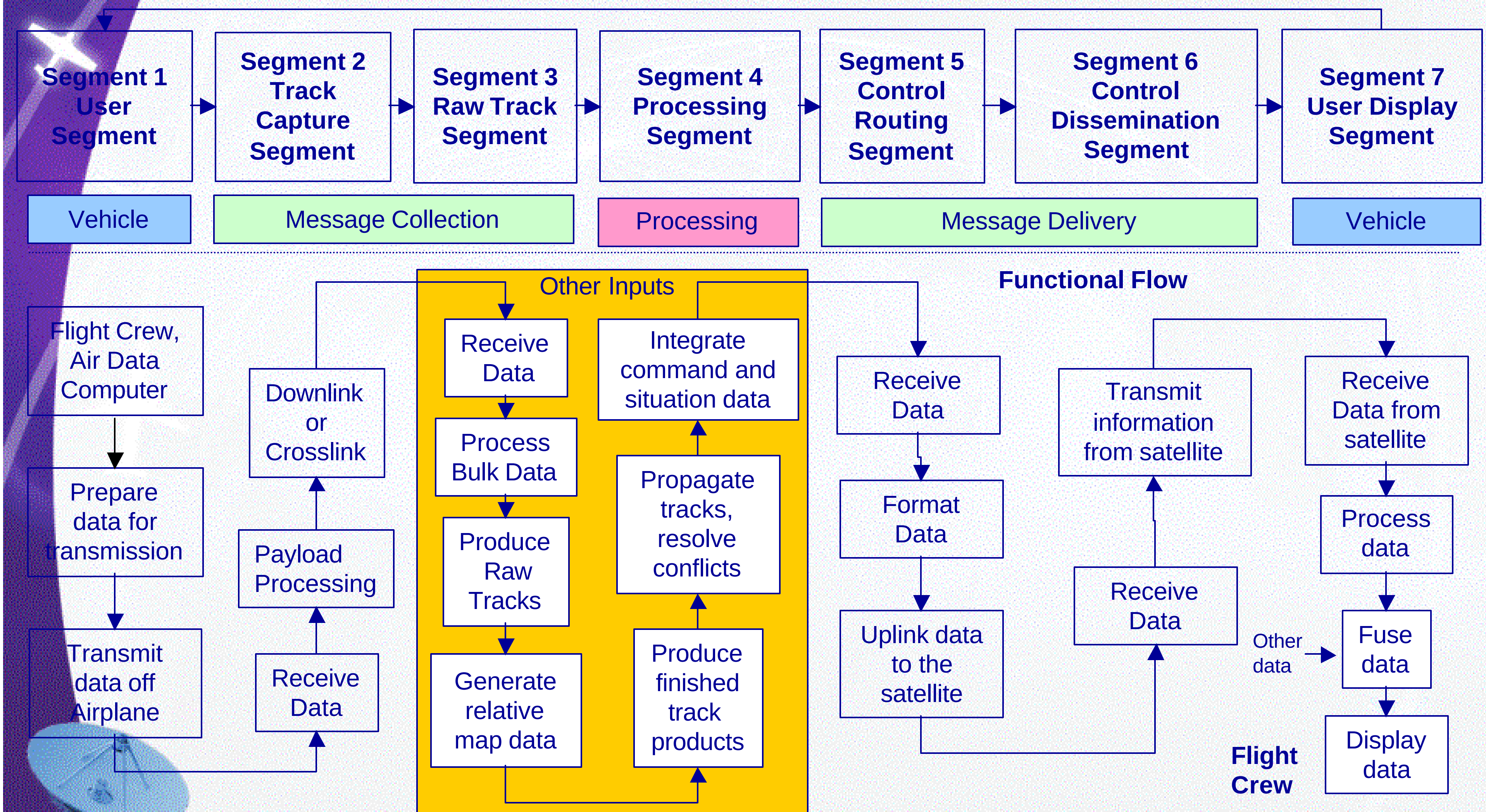
A closed loop control environment is fundamental to many advanced ATM applications, therefore:

Application demonstrations can be developed based on the assumption that a closed loop capability will exist, but,

System demonstrations need to be conducted to understand how to build, verify and use a closed loop message flow between aircraft, controllers, and owners / operators to achieve the level of performance and trust that all participants in the process will interpret as a *safe, seamless, real-time, global capability*

The demonstration environment must be an open architecture that welcomes globally emerging technologies and applications

DOS Functional Flow



Technical Thrusts

- Safe
- More growth
- Less delay

Trajectory based flight management applications on a common information network

True Track

Identify track errors inherent in different flight management, navigation, and radar systems

Work within the [flight] community to establish a common quality metric for aircraft trajectories

Situational Awareness

Establish common situational awareness applications that all users can access responsively

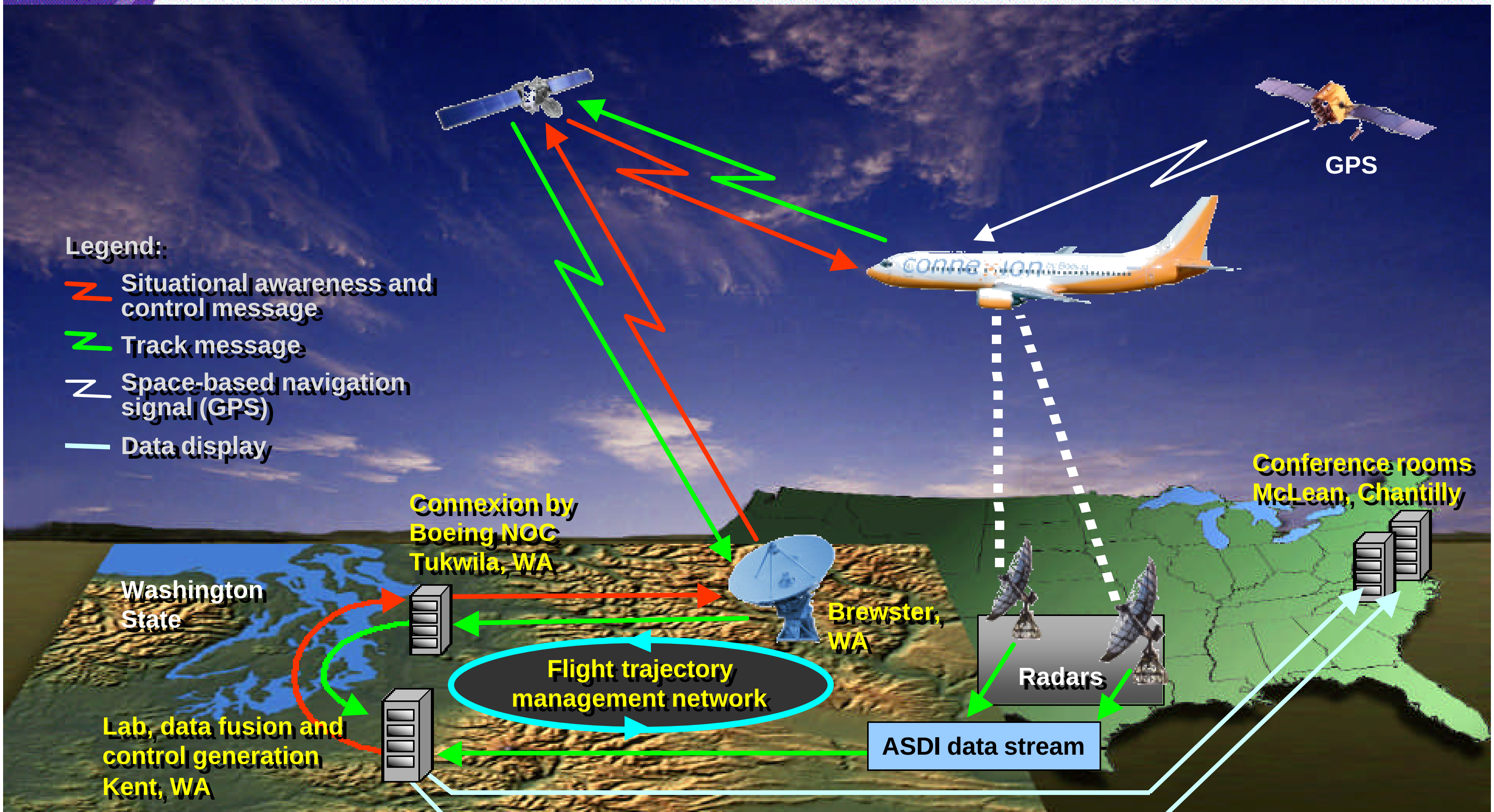
Closed Loop

Establish a closed loop IP-based network that provides near real-time performance through all phases of flight operations

Demonstration 1.0 Objectives

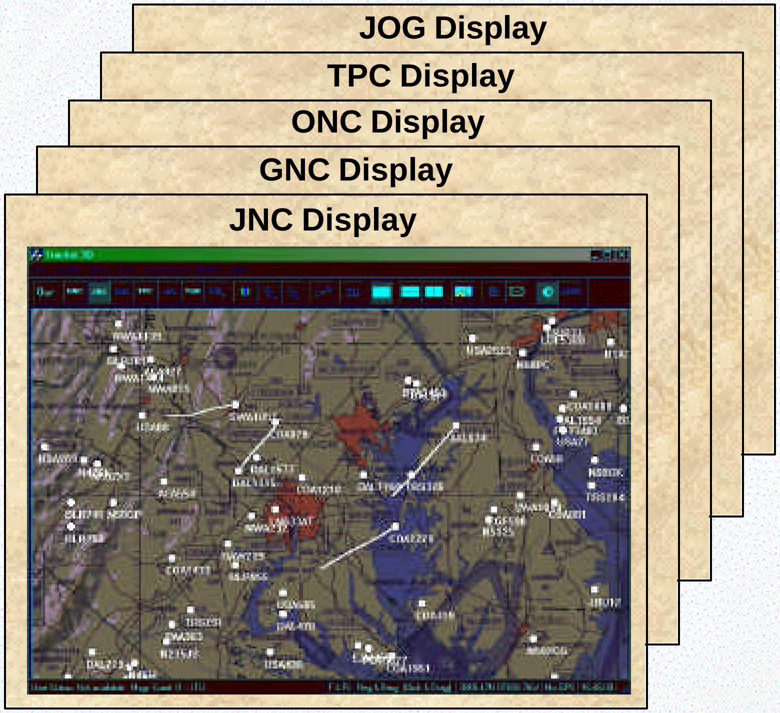
- True Track – Identify and characterize the inputs for a true track characterization algorithm for current and projected positions
  - GPS taken from on-board the aircraft
  - Aircraft Inertial Reference Unit (IRU)
  - Ground Generated Radar Tracks
- Situation Awareness Display - Display aircraft flight path and rapidly recognize aircraft deviation from flight plan
  - Responsive intentions message
  - Common data base for all displays
  - Instantaneous velocity vector (future capability)
- Closed Loop - Demonstrate a closed loop information cycle
  - Identify time components of closed loop information cycle (communication, processing).
  - Compare closed loop cycle time with 4 second benchmark

Demonstration Concept



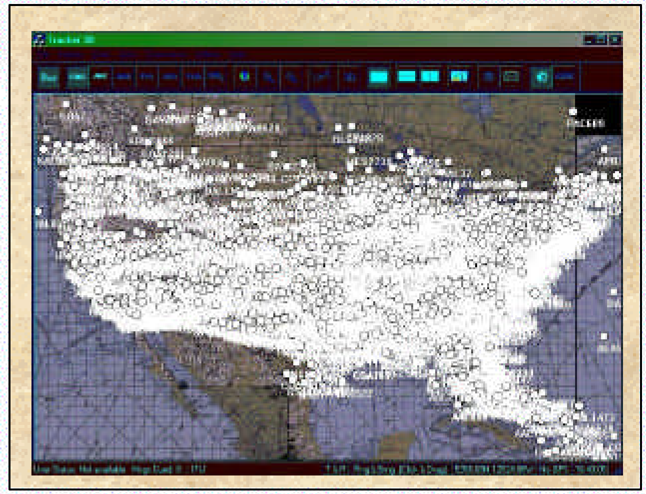
COTS Demonstration Displays

Tracker Display



- Multiple Map Selection
- Data History Tracks
- Air / Ground Centric Displays
- Aircraft Information
- Interactive chat

AADS Display



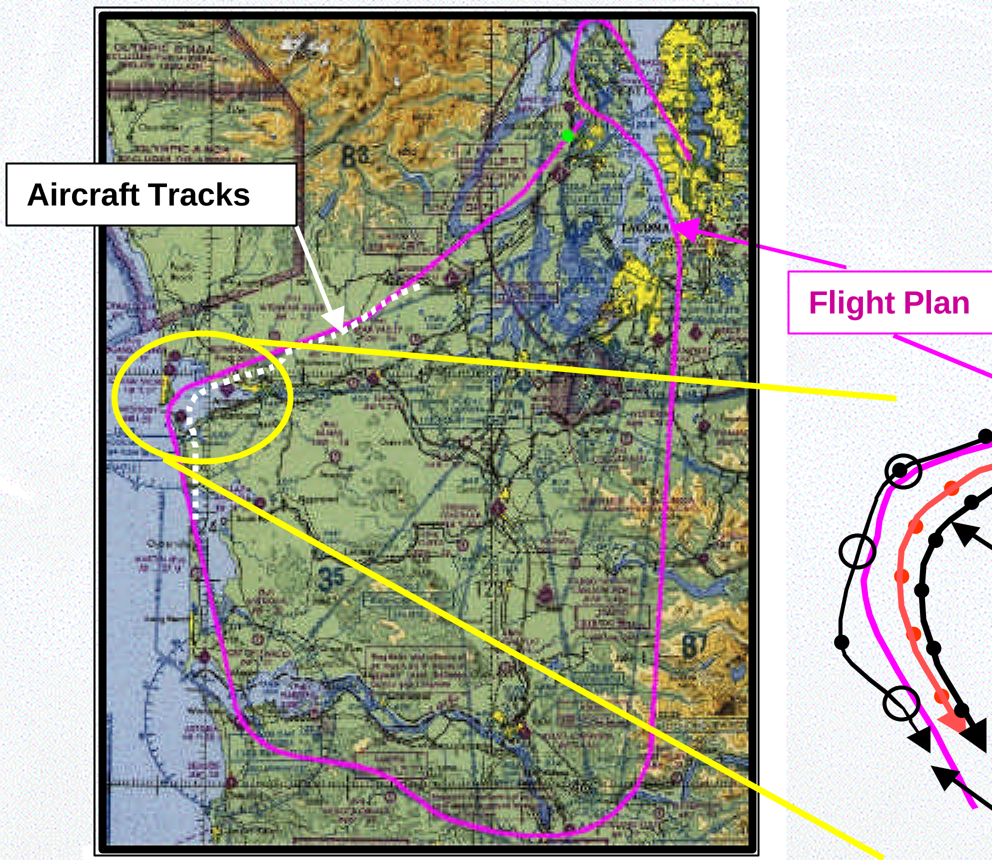
- Map Line Drawing
- Ground Centric Display
- Data Track Extrapolation
- Display Rate Selection

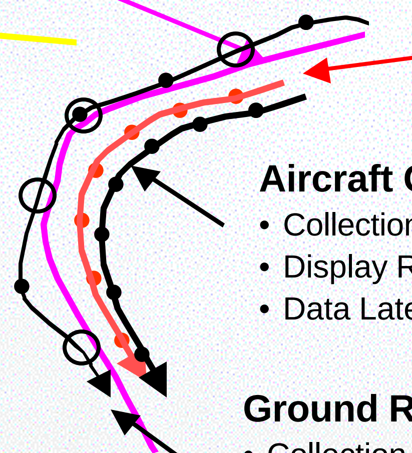
True Track Objective

- Definition: True Track – Accurate and timely aircraft trajectory (position in latitude, longitude and altitude to 100m 2σ, velocity to TBD accuracy, acceleration).
- Challenges :
  - Multiple position and time sources of the same aircraft
  - Varying data resolution and accuracy
  - Varying data latency
- Demonstration:
  - Display multiple (ambiguous) aircraft positions.
  - Calculate data latency values for each data source.

True Track Objective

True Track Demonstration - From three different aircraft location data collection schemes observe the differences in track and calculate latency.





Aircraft IRU
- Collection Rate = 1Hz
- Display Rate = 10 per min
- Data Latency < 2 sec

Aircraft GPS
- Collection Rate = 1Hz
- Display Rate = 10 per min
- Data Latency < 2 sec

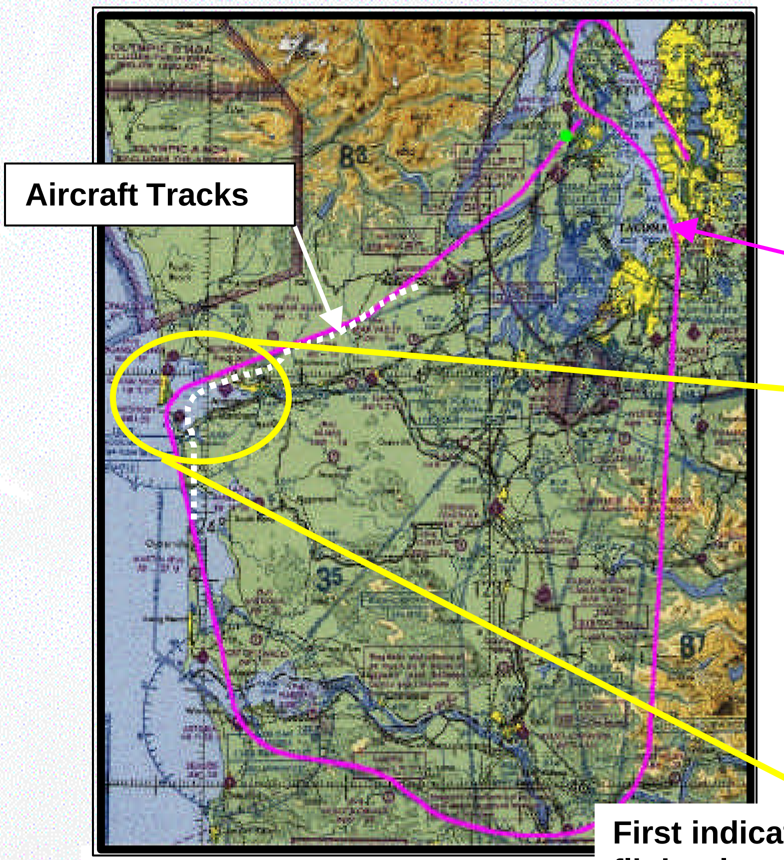
Ground Radar
- Collection Rate = 1 per min
- Display Rate = 10 per min
  (Extrapolate from Flight Plan = ○)
- Data Latency ≈ 30 sec Average

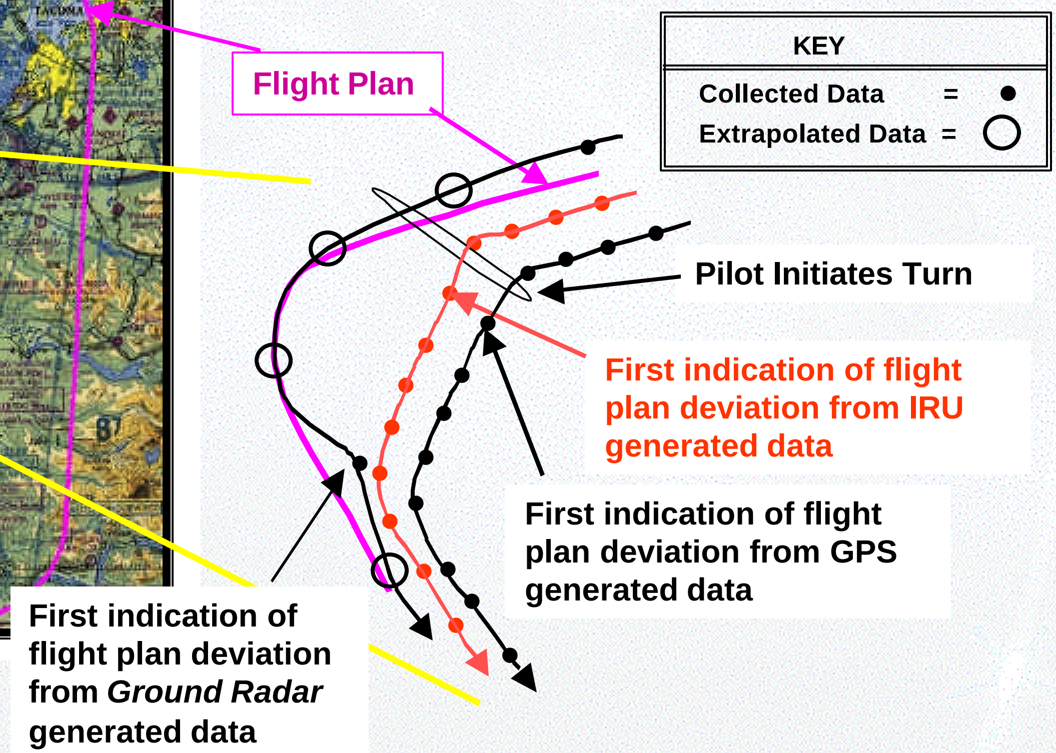
Situation Awareness Objective

- Definition: Situation Awareness – Timely and accurate display on the ground of aircraft(s) flight path and recognition of intentional or unintentional departure from approved flight plan.
- Challenges :
  - Timely recognition of aircraft deviation from approved flight plan
- Demonstration:
  - Display aircraft flight path via multiple reporting sources.
  - Display aircraft deviation from flight plan

Situation Awareness Objective

Flight Plan Deviation - Initiate flight path change and observe the time delay until changes are reflected in data shown on the display.





Closed Loop Objective

- Definition: Closed Loop – Recursive information cycle between aircraft and ground.
- Challenges:
  - Timely update of situation awareness display
  - Fusion of multiple source data
  - Identify time elements necessary to complete one information cycle from aircraft to ground and return.
- Demonstration:
  - Display ground integrated aircraft data
- Post Demonstration
  - Calculate closed loop cycle time and compare to benchmark value of 4 seconds
  - Document time element components

Closed Loop Objective

Closed Loop - Demonstrate a closed loop information cycle

- **Collect flight data on aircraft (wall clock time, IRU / GPS time, position)**
- **Archive flight data on aircraft**
- **Transmit flight data from aircraft to spacecraft to ground facility**
- **Fuse flight data with other data**
- **Transmit fused data from ground facility to spacecraft to aircraft**
- **Archive fused data**
- **Display fused data**